# HyperLogLog: Analysis and implementation of an improved algorithm

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# Introduction

Cardinality estimation problem :

- The naive solution does not scale !
- Several alogorithms have been proposed

Today, we'll talk about :

**HyperLogLog++ (call it HyperGoogle)**

Improvement of the HyperLogLog

# Hyperloglog

The approach of the HyperLogLog :

- Randomization using a hash function
- Observation of the maximum of the number of leading zeros
- Stochastic averaging

The result is then subjected to corrections

- Small range correction
- Large range correction

# Bias estimation and correction

Transition to 64 bits → an increase of the efficiency area

## Bias

The observed bias depends on the cardinality estimated. A correction then can be computed

- Bias estimation
- Store them into a file
- File loading
- Linear interpolation

# Memory optimization

- How to use the least memory possible
- Different kinds of optimization
- Depending on the number of values we want to stock
- We use a bitmap

### Three type of representation

- Dense representation
- Sparse representation
- Delta varint encoding : use the sparse representation

# Dense representation

$$\underbrace{010011}_{\text{value for index 0}}\underbrace{100000}_{\text{value for index 1}}\underbrace{011100}_{\text{value for index 2}}$$

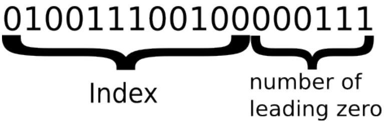
## Pros

- Use the least possible amount of bits per value
- No index is stocked
- easy to access data
- Memory size of the bitmap constant

## Cons

- When only few items are added, takes a lot of unnecessary space
- When checking for empty indexes, the whole bitmap needs to be read

# Sparse representation



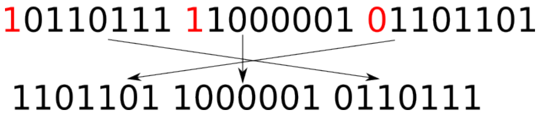
## Pros

- Size of the map will fit the number of values we have

## Cons

- It needs to stock the index AND the value
- Results in 20 bits for P = 14 and int 64

# Delta varint encoder and decoder

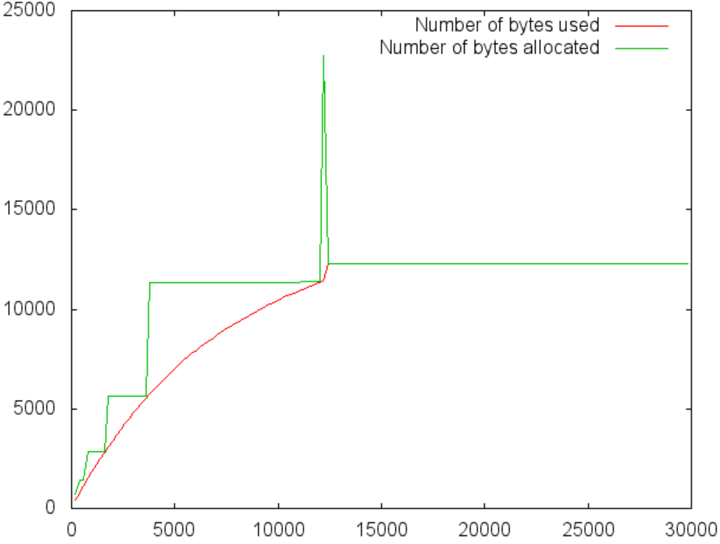


10110111 11000001 01101101

1101101 1000001 0110111

## Principles

- Improves the sparse representation
- Will use the difference between current value and previous one
- It is used in order to decrease the sparse size



Number of bytes used and allocated by our bitmap in function of the number of addItem() calls

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- It works !
- Et voila

# Bibliographie

- **P. Flajolet, Éric Fusy, O. Gandouet, and F. Meunier, HyperLogLog : the analysis of a near-optimalcardinality estimation algorithm**. In *In Analysis of Algorithms (AOFA)*, pages 127–146, 2007.

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